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SELF-ALIGNING PLANETARY GEARING

Victor W. Peterson and Paul Bancel, Indianapolis, Ind., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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Our invention relates to planetary gearing, particularly to planetary reduction gears of high power capacity to weight ratio such as are used in the drive from gas turbine aircraft engines to propellers. The invention is primarily directed to the provision of such gearing which is self-aligning so as to equalize loads on the teeth of the gears. By virtue of the invention unequal distribution of loads between different portions of the teeth axially of the gear, which may result from inevitable inaccuracies in machining and from distortion of the structure with variations in load, are eliminated or minimized. As a result, the structures may be made much lighter for given power capacity and the endurance of the gear is greatly improved.

The principal objects of the invention are to provide improved, lighter, and more reliable planetary gearing and to provide planetary gearing which is self-aligning so as to accommodate gear tooth contact to distortions under load and manufacturing tolerances.

By way of brief introduction to the nature of the invention in its preferred embodiment, the gearing comprises a sun gear, a planet carrier mounting a number of planet gears meshing with the sun gear, and an internally toothed ring gear meshing with the planet gears. The axis of the planet carrier is fixed and the centers of the planet gears are fixed with respect to the carrier, but the axes of the planet gears can swing universally with respect to the carrier. The ring gear is mounted so as to be held against rotation but with limited freedom for movement radially of the planet carrier axis and swinging movement relative to that axis. The sun gear is mounted with slight freedom for radial movement on its shaft. As a result, the sun gear and ring gear are located by the planet gears which, in turn, are located by the planet carrier. The planet pinion axes can swing in any direction to accommodate the tooth contact between the planet gears and the other two gears to the relative positions of these gears.

This flexible self-aligning structure is accomplished with a minimum of mechanical complexity and weight.

The nature of the invention and the advantages thereof will be more clearly apparent from the succeeding detailed description of the preferred embodiment of the invention with reference to the accompanying drawings in which:

Figure 1 is a sectional view of a planetary reduction gear taken on a plane containing the axis of the gearing;

Figure 2 is a greatly enlarged detail sectional view taken on the same plane as Figure 1;

Figure 3 is a fragmentary transverse sectional view taken on the plane indicated by the line 3—3 in Figure 2;

Figure 4 is a partial developed view of an arcuate wavy spring; and

Figure 5 is a perspective view of the spring.

Referring to Figure 1, the reduction gear is housed in a case **10** which is shown in part. Projecting from the nose of the case is a hollow propeller shaft **11** mounted in a radial bearing **12** and a thrust bearing **13**. The propeller shaft **11** is integral with the forward cone or spider **14** of a planet carrier indicated generally by **16**. Spider **14** is fixed by bolts **17** and spacer sleeves **18** to the rear spider **19** which is integral with a stub shaft **21** rotatably mounted in a radial bearing **22** supported by diaphragm **23** of the case. It will be seen, therefore, that the propeller shaft and the planet carrier constitute a unitary structure rotatable about the axis defined by bearings **12** and **22**. Power is supplied to the gearing by a hollow shaft **24** on which is mounted the sun gear **26**. The sun gear meshes with planet gears **27**, preferably five in number, rotatably mounted in the planet carrier **16**. The planet gears in turn mesh with a non-rotatable ring gear **28** supported by an annular member **29** which connects it to a supporting ring **31** fixed to the reduction gear case.

Considering now the mounting of the gears in more detail, the sun gear **26** and shaft **24** are connected by mating axial splines **33** which are of such degree of looseness as to permit a slight radial movement of the gear with respect to the shaft. The sun gear is held in place by snap rings **34** and **36**. The planet gears **27** are mounted on non-rotatable shafts **37** fixed to the front and rear spiders of the planet carrier. The shafts **37** have an enlarged central portion which lies between the spiders **14** and **19** and reduced end portions **38** which fit in bored openings in the spiders and are threaded to receive collars **39** which clamp the spiders against the central portion of the shaft. Collars **39** are locked by rivets **41**.

The interior of the planet gear defines a spherical bearing race **42** and the exterior of the shaft **37** defines two concave races **43**. Barrel-shaped rollers **44** roll in the races **43** and engage the race **42**. As will be apparent, since the rate **42** is spherical, the planet gears may swing universally about their centers. However, the center is fixed with respect to the planet carrier by the two rows of rollers. It may be noted that the shafts **37** are a close fit in the openings in the spiders **14** and **19** which receive them and that these shafts thus provide a rigid connection between the two spiders. Bolts **17** are located between the planet gears and provide an additional connection.

The ring gear **28** is coupled to the annular support **29** and the support to the mounting ring **31** by similar splined connections providing a floating mounting for the ring gear. Since these splined connections are of large diameter and small axial extent, they may swing as well as slide axially, with the result that the ring gear is freely floatable sufficiently to accommodate any needed adjustment. The nature of these connections will be more clearly apparent from the enlarged showing of Figure 2 which shows a fragment of the lower front edge of the ring gear **28**. The gear is machined with a groove **46** and the portion adhead of the groove has splines **47**. The rear end of the coupling member **29** has splines **51** meshing with the splines **47** and a groove **52** rearwardly of the splines. The rear ends of the splines define rearwardly facing shoulders or abutments. The rear faces of grooves **46** and **52** define forwardly facing abutments. In order to prevent shake or rattle of the parts, four approximately quarter circular wavy springs **54** are lodged in the grooves **46** and **52**. These springs are shown also in Figures 4 and 5. Each spring has three slight bends in it indicated at **56** so that, when viewed as in Figure 4, it is an extremely flat W. Thus, with the spring in place, the ends and the central hump **56** engage the rear abutment and the other two humps **56** engage the forward abutment. Since the springs are relatively light and small in comparison to the rest of the structure, they do not offer any substantial resistance to shifting or cocking of the splines.

To provide for insertion of the springs **54**, the rear